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ABSTRACT

Selected college programs designed to increase students' science literacy are described, and perspectives on science education are addressed in an article by E. James Rutherford, "Sputnik, Halley's Comet, and Science Education." The article suggests that leadership and consensus are needed at the national level to improve science education and to prepare graduates for a world of science and technology. Following the essay, specific programs are described. Franklin and Marshall College implemented a new general education program, and science courses aim to provide students with an understanding of scientific principles, practices, and reasoning. The University of Chicago's core curriculum calls for requirements in the biological and physical sciences. West Virginia University integrates guided design projects with lectures and laboratories in physical science courses, which are designed to develop an understanding of societal problems. A new focus at Syracuse University introduces students to the sciences, aspects of engineering and applied science, and sociotechnological issues as part of a new general education curriculum. Reducing science anxiety is another goal. At the University of Wisconsin, Madison, Integrated Liberal Studies (ILS) courses provide an overview of important aspects in western civilization, and science courses are primarily designed to provide an understanding of how science functions. S. N. Postlethwait at Purdue University has developed a science paradigm for his freshman botany course. Finally, faculty at Iona College have developed a set of science courses for nonscience majors. Additional programs are briefly described, along with resource materials. (SW)

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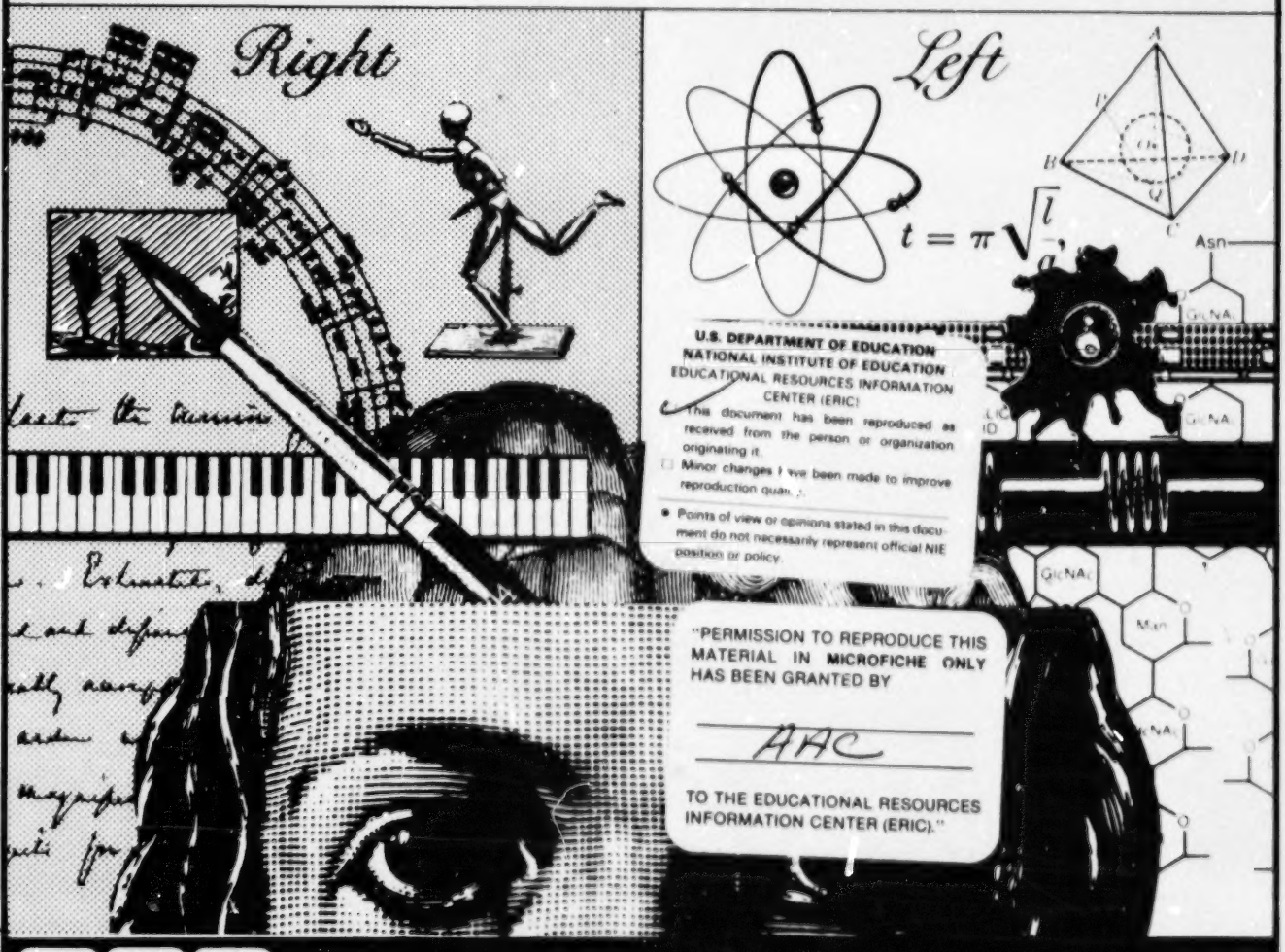

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This *Forum* issue continues the discussions begun at AAC's June 1982 conference on Science and Technology Education for Civic and Professional Life—The Undergraduate Years.

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Science Literacy for All Students

In a world with increasing technological and scientific complexity, science literacy must be more than the understanding of a few basic principles in the biological or physical sciences. Rather, it must encompass the ability to apply an understanding of science principles, methodology, capabilities, and limitations to the wide range of decisions students will face both as citizens and as professionals.

The colleges and universities described in this issue have accepted the challenges of the future and are attempting to ensure that all of their graduates are scientifically literate. In many of the programs students are learning how and why scientists do what they do so that they can evaluate the reliability of scientists' conclusions. Other programs emphasize technological literacy as an important component of education for informed citizenship, and some focus on the application of science to current problems. All recognize that science literacy is necessary for both science majors and nonscience majors, no matter what professions they pursue.

Sputnik, Halley's Comet, and Science Education

by F. James Rutherford
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Things seem to come in cycles—sunspot activity, locusts, hula hoops, comets, educational reform. Halley's Comet, last seen in 1910, is due back and should be visible this October through powerful telescopes. October is the anniversary month of Sputnik as well.

It was just twenty-five years ago on October 4th that we were jolted by the news that the Soviet Union had successfully launched an earth satellite. In an instant we became aware of what some educational leaders had been claiming for several years, namely that science education in the United States was weak and inadequate for the times. Now, a quarter century later, we are once again hearing that our deficiencies in science education have put us at risk.

What are we to make of this? Are our troubles in science education merely cyclical, the swing of the pendulum? In seeking an answer let us reflect briefly on both Halley's Comet and Sputnik.

Comets are fabled creatures. The one bearing Edmund Halley's name was, in the scientific way of things, discovered by him, and then again, it was not. Its first documented sighting was by the Chinese in 239 B.C. Every reappearance since then has been found in both visual representations and in written records. Giotto must have seen this comet in 1301 for he depicts it as the Star of Bethlehem in his fresco "Adoration of the Magi." It was represented again in the famous Bayeux Tapestry commissioned to commemorate William the Conqueror's victory in the Battle of Hastings in 1066 and, nearer at hand, Mark Twain said, "I came in with Halley's Comet, and I'll go out with it." And he did. Twain was born in 1835 and died in 1910.

Edmund Halley (1656–1742) examined the historical records available to him and was able to calculate accurately the period of this comet. It is because of his work and what followed that we now know that we will see this most famous of all comets in its full glory in February 1986, and we know just when it will return for all future generations.

But let's turn things around for a moment by imagining that the comet could observe us. Would it recognize today's world as being the same one it "visited" in 1910 (let alone in 1835 or 1758)? Hardly. Consider: the world's population will have jumped from about one-and-one-half billion to five billion. The things people will seem to be using for transportation, communication, research, construction, recreation, anything, mostly did not exist in 1910—jet aircraft and gas guzzlers, super highways and intercontinental missiles; four generations of computers; robots assembling robots; earth satellites and particle accelerators; T.V. and L.P.; the bomb. And the work people do—having changed in the interval from farming to manufacturing to service—and the issues that confront them—nuclear annihilation and the population explosion being the two frightening extremes that encompass others such as resource depletion and environmental degradation—are radically different from what they were 75 years ago.

If we go back still another Halley cycle, comparing the world of 1910 to the world of 1835, once again the comet would report large differences, but they would be less dramatic. And 1760 still less, and so on back to the 19 trips to 239 B.C., or further. Not only is the world the comet returns to each trip different from the way it was the time before, but the magnitude of the difference is greater, probably exponentially so.

This kind of comparison tells us two things about the world of the future. It tells us that we cannot now accurately describe the world as it will be when Halley's Comet next returns in 2062. Of course it will be different from today's world; but in precisely what ways we cannot predict any more than the world of 1985 could have been foretold in 1910. But this we do know: the changes that will be brought about in our culture and in our way of life, will have more to do with the utilization of science and technology than with anything else. If our civilization is here next time around, it will be a world that more than ever before, more than even now, will be based upon science and technology—for better or worse. If human civilization is not here, a real possibility, it will be because we failed to come to terms with ourselves as the generators of knowledge and the users of technologies.

Translated into educational terms this means that we must now learn how to prepare the graduates of our schools and colleges for a world of science and technology. The evidence tells us that we are not doing so. We see test scores falling, students avoiding science and mathematics courses, fewer students electing science majors, a collapse of the teacher preparation enterprise in science and mathematics, the obsolescence of the science and mathematics curricula, and a cutback in support of science teaching. Where, one might plaintively ask, is *our* Sputnik, to wake us up, to get us going?

One answer is that we already have it, and it is called Sony or Nissan or Mitsubishi. The threat this time may not have appeared so suddenly, but it is no less expected and is much more fundamental. It has to do with the increasing determination of Japan, the Germanies, the Soviet Union, and many other nations to seize the technological initiative, just at the moment when we are reducing our commitment to the very science and technology that is the basis for a strong economy and for world leadership.

Another answer is that while Sputnik was the spark that led to a national effort to improve science education, it was not an unmixed blessing then, and it is not likely to work today anyway. Two crucial factors are missing: leadership and consensus. In contrast to the national leadership that existed following Sputnik, including a mandate from President Eisenhower, the federal government is now in retreat educationally, if not in disarray. The President of the United States has made it clear that whatever the problem is, it is a matter to be addressed by the individual states and local school districts, with perhaps some help from the private sector. The U.S. Department of Education is barely able to survive let alone foster anything as creative as the massive federal program in 1958 to upgrade science, mathematics, and foreign language training, and the education programs at the National Science Foundation have been essentially eliminated. There is no single national voice, no real call to action from the top.

Furthermore, even though we seem gradually to be registering concern about our situation, we have been unable to agree on what to do about it. We accuse our business people of not being enterprising enough, our government of putting too many shackles and restraints on our people and institutions; we claim that our workers are not good enough or do not work hard enough, we point to the unfair competition from former friends abroad, and we seem to have lost confidence in public education. In short, unlike before, there is no broad consensus that science and mathematics education *for all* is fundamental and essential. We lack a popular mandate.

But even if we could have "our own" Sputnik to motivate us, I doubt that we would want it. Think what happened last time. Almost from the outset our response to Sputnik was as though we were in a high-stakes sporting contest. The U.S.A. and the U.S.S.R. were the only competitors in "The Space Race." Our task, our challenge, was to become dominant in space—which we soon came to believe meant getting a man to the moon first. To win we would have to invest heavily in space technology, and also accelerate the production of first-rate scientists and engineers, which is to say train more young people for technical careers.

That was where we went awry educationally. By casting our response to Sputnik in terms of a particular contest rather than of longer-range national goals, we made it probable that the public would lose interest in science education once the contest (as perceived) had been won. What is worse, by concentrating on the production of scientific and engineering manpower we were diverted from the effort already underway to strengthen the science education of all our students. What the country needed then and what it needs even more now is a society made up of high school and college graduates who can come to terms with the scientific and technological realities that confront them daily—as citizens, as workers, as human beings. Scientifically and technologically literate citizens form the necessary base upon which to build and sustain a democratic society in a technological world, and that is what we need to work toward.

The lesson of Sputnik is its failure to catalyze a broad-gauged and lasting reform movement in science and technology education. Every student needs a good general education, and in these times such an education must pay sub-

stantial attention to science and mathematics and their applications. In this the undergraduate institutions have a heavy responsibility, for it is through them that the professionals and the business and political leaders of the 1990s and beyond will pass. Graduates of the next quarter century will determine whether when Halley's Comet returns in 2062 there will be a world of human beings at all, and, if so, what kind of world it will be.

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Franklin and Marshall College

Scientific Inquiry and the College Studies Program

With the development and implementation of a new general education program at Franklin and Marshall College, faculty members have reaffirmed the college's commitment to the liberal arts and the goal of education for citizenship, says Bradley R. Dewey, dean of faculty affairs and professor of religious studies. Scientific inquiry, one of the program's seven areas of study, fits into this concept by emphasizing science literacy, or what Dewey defines as "mastery of the state of the art," for informed citizenship.

Faculty members demonstrated their support for the College Studies Program, the new general education requirements, by formally approving the criteria they and their peers had established for courses satisfying requirements in each of the seven areas. Dewey emphasizes that all faculty members voted on all criteria, not just those applicable to courses in their own department or division.

Thus faculty members approved criteria for coursework in scientific inquiry, social analysis, historical studies, literature, foreign cultures, arts, and systems of knowledge and belief. The college catalog defines the scientific inquiry requirement as "science courses which provide the students with an understanding of scientific principles, practices, and reasoning." College studies literature courses "introduce . . . the processes of literary analysis and Western literary tradition," while social analysis courses "enable the student to comprehend human social behavior." Students must complete two courses in both scientific inquiry and social analysis and one course in each of the other areas.

The move to all-college criteria for departmental courses began in the late 1970s when a faculty task force conducted a two-year study of the college's distribution requirements in the natural sciences, social sciences, humanities, and fine arts. The task force proposed the seven areas of study and recommended that all faculty members have a voice in establishing the criteria for courses receiving college studies credit.

During the next year and a half faculty members debated and revised the college studies proposal. Instructors drew on the task force's suggestions in developing a set of criteria for each area. In fall 1980 the full faculty approved all criteria.

"The criteria were designed to insure the general education orientation of each course," says Dewey, "and were a significant departure from our usual semi-laissez-faire approach to faculty course design." To insure the proper implementation of the new program, the faculty members elected a five-member College Studies Committee charged with reviewing all courses proposed for college studies credit. Although there are no common criteria for the study areas, there are several common goals, according to Dewey.

"All courses must be pitched toward the general education audience," he says. "They are self-contained units rather than building blocks for insights realized in a sequence's later courses. Faculty members must keep in mind that their course may be a student's first and only course in that area of study."

Scientific Inquiry Criteria

These goals are met by 17 science courses which have been determined by the College Studies Committee to "involve the student in a systematic study of the physical and/or biological world." To accomplish this, the faculty-approved criteria state that the courses must "introduce major concepts of a field of science, providing insight into the breadth of the discipline and its relationship to other disciplines;" "involve systematic data collection using experimentation and/or observations, with one or more of these sets of data being treated in a quantitative manner;" and "address relationships between exemplary scientific principles and the historical and cultural context in which they arose, and public policy issues."

Other criteria focus on the limitations of data and "the relationships among experiments, models, theories, and laws." In addition, each scientific inquiry course must include laboratory work.

As with the more than 50 courses which have received committee approval in the other areas, college studies science courses are either new courses or revised versions of standard offerings. Individual faculty members, in concert with departmental colleagues, prepare courses which meet both the "spirit and letter of the law," according to Dewey. Substantial changes in the existing courses include greater attention to public policy issues and the limitations of data and the broader general education orientation, he says. The Surdna Foundation, the Pittcairn-Crabbe Foundation, and a joint Hewlett Foundation-Andrew W. Mellon Foundation grant funded faculty release time for College Studies Committee activities and course development.

Approved science courses include Descriptive Astronomy, Introduction to Oceanography, The Structure and Composition of Matter, Introduction to Chemical Reactions, Descriptive Physics, and Introduction to Principles of Behavioral Processes. The departments of mathematics and astronomy, biology, chemistry, geology, physics, and psychology all have courses which meet the scientific inquiry criteria.

For example, Life Processes is a revised biology course which has received committee approval and is intended for nonscience majors. The principle concepts introduced in this course on plant and animal biology include evolution, metabolism, genetics, physiology, and ecology. Instructors refer to the fields of chemistry, biochemistry, anthropology, and psychology in lectures on cell structure and function, Mendelian genetics, and human behavior.

Readings and discussions on such topics as Darwin and

evolutionary theory, predetermination versus epigenesis, and climate and biogeography "illustrate the relationships which exist among experiments, models, theories, and laws." Laboratory exercises illustrating natural selection, photosynthesis, and transpiration provide opportunities for systematic data collection and help illuminate and test biological principles and theories, according to a course description submitted by the biology department to the College Studies Committee. The description also states that faculty members discuss limitations of data by offering "alternative interpretations of famous experiments where such reinterpretations have been historically significant."

Students learn about the historical and cultural context of the course in lectures on Darwin, Mendel, Watson, and Crick. Public policy issues relate to course discussions on the effects of human population on the environment and nutrition and human food chains.

In another revised biology course, Cellular and Molecular Biology, instructors cover such topics as biological molecules, metabolism, photosynthesis, and cellular structure and function. Students read about historical milestones in the field of cell biology and learn how chemistry and physics contributed to its development. They collect and record quantitative data and/or observations from laboratory exercises on bacterial growth, cell and tissue morphology, and enzymes.

Biology and Behavior of Living Systems is a new course jointly designed and offered by the biology and psychology departments. Offered for the first time in spring 1982, the team-taught course is intended as a second course for nonscience majors who have taken either Life Processes or Introduction to Psychology, another scientific inquiry course. Instructors emphasize "both biological and psychological perspectives in analyzing levels of organization ranging from molecules to human social groups," according to the course description. Sections deal with homeostasis and stress, information-processing systems, and reproduction and related topics. In the second section, for example, discussions focus on molecular biology, neurophysiology, and interpersonal and intergroup communication. Faculty members believe the course is both "useful and stimulating" for the nonscience major who can "delve further into a discipline he or she has already found attractive" while being "simultaneously challanged with a complementary form of inquiry into the same or analogous phenomena," according to a course report.

Scientific inquiry courses in the geology department include Introductory Geology, History of the Earth, and Introduction to Oceanography. The former course includes lectures on classes of rock and geological phenomena such as earthquakes, continental drift, and glaciation. History of the Earth presents a chronological examination of the earth's evolution along with the principles of historical geology.

In each of the scientific inquiry courses, as well as all college studies courses, students must write two papers for a total of eight or more pages. The approach to this requirement varies from department to department, according to Dewey. Many instructors ask students to prepare laboratory reports in a prose-oriented style, others place more emphasis on library research papers, and some combine the two approaches.

Lectures and Workshops

In addition to the new writing requirement, the inclusion of public policy issues and the historical and cultural context of scientific principles is a new aspect of many of the scientific inquiry courses, according to Dewey. To emphasize this new focus, administrators will invite visiting scientists during the next three years to present public lectures on such topics as the history of geology and the changing views of the earth during the last century. Dewey praises the work of the college's sole History and Philosophy of Science Program instructor who has already conducted seminars to prepare science faculty members for integrating historical and cultural perspectives into their courses.

"By emphasizing science as a human activity we show students that there is not an automatic unfolding of science," says Dewey. "Science is people pushing insights and discoveries along." The new focus also will present science as an evolving process rather than a set of absolute truths and show the integration of science with society, according to Dewey. In addition to giving public lectures, the visiting scientists will conduct faculty seminars, visit classes, and meet informally with students.

Administrators also plan faculty seminars on public policy issues for summer 1983. "We will invite people who can relate their science to federal or state policies to conduct the seminars," says Dewey. "We acknowledge that our degree of emphasis on these topics is new, and we want to stimulate the faculty members' interest and give them the information they need to do a good job."

It is too early to judge student interest in the year-old College Studies Program, says Dewey. He notes that students accept the importance of the requirements but dislike the writing assignments, which are the most visible addition to the courses. The College Studies Committee will review the program's progress during the 1982-83 academic year.

Additional plans include the integration of technological literacy, according to Dewey. Administrators have submitted a proposal to the Alfred P. Sloan Foundation's new science program and anticipate offering a series of faculty workshops on quantitative analysis. Technological literacy will relate to the scientific inquiry and social analysis criteria involving quantitative data, according to Dewey.

"Technological literacy will help students understand the impact of science on society," says Dewey, "and link up with the citizenship function of the College Studies Program."

In reflecting on the new general education requirements, Dewey states that the most innovative aspect of the program is the entire faculty's participation in setting criteria for departmental courses. He says: "Although the process created some productive tensions caused by department traditions and authority, faculty members acknowledged the importance and necessity of all-college insights in shaping the criteria, and endorsed the program." *P.B.*

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A Tradition of Core Curriculum Science Requirements

At the University of Chicago all students take one year of a biological science and one year of a physical science to fulfill core curriculum requirements that have been a long standing tradition at the college. Faculty members design the core sequences in the sciences and the humanities "to introduce the methods and conceptual structures of four major divisions of human knowledge," according to the college catalog. The year long, three-course science sequences delve into specific concepts and teach students "how scientists think and why that is useful," says Lorna Straus, professor of biology and member of the curriculum committee.

The significant differences in the structure and approaches to science literacy between the undergraduate divisions of the Biological Sciences and the Physical Sciences reflect the differences in the two disciplines. "Biology is becoming one discipline . . . that has not happened yet in the physical sciences (which) is made up of different bodies of knowledge," says Straus. The biological division incorporates the various disciplines of biology and does not distinguish between courses for nonscience majors and science majors. The physical science division does differentiate and is departmentalized.

Common to all of the 17 core biological sequences are four topics that students must be exposed to by the end of each sequence. The topics are the physical structure of organization of a living thing, how these parts work in conjunction with each other, continuity from one generation to another (genetics), and evolution—"how there is indeed change over time in the heritage of a particular organism," says Straus. Every sequence "aims to illustrate the mode of inquiry employed by biologists," according to the course catalog. Some sequences do not have laboratories, although students must take a common core laboratory if their sequence does not include one. These are self-paced, and students must complete six experiments during one of the three semesters during the academic year.

Although student lore claims that some biological science courses are better suited for nonscience majors and others for science majors, "any of the sequences will prepare a student to go on to the upper level biology courses required for majors," says Straus. Most of the courses have a fairly even distribution of science and nonscience majors and sometimes students become majors after completing a sequence. Straus has witnessed the advantages of a mixed group of students in her own course, Structure and Function, which discusses the structure and associated functions of humans' and other animals' organs. She finds that humanities and social science students raise questions about the ethics and economics of the dialysis machine, for example. "Biology majors would not have asked these things—they would be interested in the machine and how it compared to a real kidney," says Straus.

Science anxiety in nonscience majors is not a problem, says Straus, because all students must meet certain mathematics requirements. Students who do not qualify for calculus must enroll in a precalculus mathematics course. Straus does see "science irritation" in nonscience majors—resentment over having to take science courses. To make the courses interesting and relevant she discusses issues in the news and entertains personal questions students may have about, for example, their father's heart condition. To improve their visual images of topics discussed, which she has found lacking, she brings in real organs.

An example of a three-course biology sequence offered to both science majors and nonscience majors is Structure and Function of the Cell, Genetics and Evolution, and either Apes and Human Evolution, Neurobiology, or The Biology of the Mind. The prerequisite to this sequence is either an introductory mathematics or chemistry course. Another biology sequence is Chemical Basis of Cell Function, Defense Mechanisms, and Genetics in an Evolutionary Perspective.

Physical Sciences Division

The ongoing debate in the biological sciences division over whether to separate nonscience majors and science majors in the core sequences and require majors to take certain sequences has already been settled in the physical sciences division. Only students who enroll in a core sequence for majors may enroll in upper level physical science courses. Physical science instructors believe prospective science majors need a great deal of mathematics which would not be included in a course suitable for nonscience majors. Physical sciences division faculty members seek to give the nonscience major an in-depth introduction to one discipline in the division, such as geology or physics. "Although the student will not know the facts that pertain to the other disciplines he will have some sense of what a physical scientist does, what type of argument he finds acceptable, and how he goes about learning about his discipline," says Straus. The professors take a historical approach in part, but also emphasize the state-of-the-art techniques. Sequences for nonscience majors include Science and the Earth, Foundations of Modern Physics and Chemistry, Introduction to Astrophysics, Geophysics: The Atmosphere, Physical Geology, Evolution, and Earth History, Basic Chemistry and General Physics.

The core curriculum science requirements have changed little since 1931, says David Orlinsky, professor of psychology and social sciences, although the philosophy behind them and the ways of approaching science literacy have changed. During the 1940s the college used the case study approach to introduce students to the logic of science. Students studied and duplicated the classical experiments, such as those by Galileo, to understand the scientists' mode of inquiry, says Orlinsky. Later the college offered survey courses to help students pass comprehensive biological and physical science examinations. Now all the science courses have a contemporary research focus, and students learn how modern science developed out of the classics. This instructional approach is popular largely because the faculty members are now primarily research faculty whose main purpose is to train student scientists in their laboratory, says Orlinsky. He admits that this approach has not been an unqualified success. *T.A.*

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West Virginia University

Science for Citizen Action

In a desire "to help students acquire some of the problem-solving skills demanded of enlightened citizens in today's society," faculty members at West Virginia University (WVU), have redesigned the college's traditional two-semester physical science sequence, according to James Shuman, former visiting assistant professor in the Physical Sciences Program. Four years ago faculty members representing the Physical Sciences Program and the departments of physics and astronomy, geology, and chemistry, prepared new course activities which force students to acquire a basic understanding of scientific concepts in order to develop educated opinions on societal problems.

The activities help instructors meet the goals of the physical science sequence, says Shuman, who is now assistant professor of recreation and leisure services at Northeastern University. He lists the three goals as helping students "learn some of the basic concepts in the physical sciences, practice skills useful in gathering and analyzing scientific data, and develop a useful approach to open-ended problem-solving."

Physical science is one of several disciplines students can choose from to complete their WVU core curriculum requirements and the College of Arts and Sciences one-semester laboratory science requirement. For the core requirement students must complete 12 credits chosen from two subject areas such as biology, chemistry, mathematics, genetics, and physical science. The eight-credit physical science sequence features coursework in physics, astronomy, chemistry, meteorology, and geology.

The new activities employed by the physical science instructors to teach these subjects follow the guided design approach developed in 1969 by a WVU faculty member and applied to a variety of disciplines at schools across the country. Charles Wales, professor of engineering and education, developed guided design to help engineering students learn the decision-making process.

"Guided design is a technique for developing decision-making skills," says Wales. "It provides a model to follow and helps students move along William Perry's spectrum of development."

In guided design, small groups of students propose solutions to problems after following a step-by-step procedure for discussion and information-gathering outlined one step at a time by the instructor. Wales identifies instructional feedback as the heart of the program. As students complete each step, the instructor provides the answers a hypothetical group of students might reach after working through the same decision-making step. The instructor assures students that the hypothetical responses are not the only correct answers but rather "allow everyone to compare his or her reasoning with that of the hypothetical group," according to a study guide.

"Research indicates that, psychologically, students grow in college by confronting issues that have more than one possible answer," says Shuman. "In problems with open-ended solutions any solution is acceptable depending on what you believe or what the best evidence indicates. Guided design is set up to allow students to talk about topics which have a scientific base and to try out their ideas on other people."

Physical Science Activities

Instructors integrate guided design projects with lectures and laboratories throughout the two semesters of physical science. Shuman emphasizes that students must understand the basic science concepts related to a problem in order to successfully complete a guided design project.

Physical science instructors begin the first semester with discussions on motion and energy. They introduce students to guided design with a project that focuses on how a group of students can work together to solve such problems as a coal company's plans to strip-mine a spruce forest, which is the habitat of a rare species of wildcat. To familiarize themselves with the ten-step decision-making process employed in guided design, students analyze and identify each step in a situation that occurred several years ago in Morgantown: the city council wrote and passed a housing code after three students died in a fire because their rental housing had inadequate fire escape facilities. The ten-step process begins with "identify the problem" and "state your basic objective," continues with "generate possible solutions" and "analyze the (chosen) solution," and ends with "carry out the solution and check the results."

"The physical science guided design projects are set up on the model of student public interest research groups," says Shuman. "These groups want to get to the bottom of things and uncover the real facts so that they can form well-founded opinions." The course designers chose socially-related topics, such as the physics problem on the energy crisis, because they thought it was important for students to learn about topics which they would confront as citizens, according to Shuman.

In the physics project students examine how a hypothetical public interest research group could respond to a letter in the local newspaper advocating nuclear power as a safe energy source. They determine what facts are needed to evaluate the author's claims; gather information on such topics as energy consumption, availability of fossil fuels and solar energy; discuss possible causes of the energy crisis; decide how they could respond to the letter; and prepare a comprehensive article presenting for the newspaper a more accurate assessment of the energy crisis.

In each project students participate in a variety of activities, according to Shuman. These include group discussions, laboratory work, lecture attendance, and library research. Shuman believes laboratories are especially important because they help students understand the scientific process and appreciate what scientists actually do.

Students attend laboratories on star motion and phases of the moon in preparation for the first semester's final project, Search for Extra-Terrestrial Life. In this project students must determine whether government support for

an observatory's project to watch for signals from "little green men" is justifiable scientifically and economically and whether the methodology is reasonable.

Students study astronomy and the probability of life on other planets in order to understand the project. In the second semester they learn about chemistry and geology in preparation for projects on water pollution and solid waste disposal. A section on meteorology does not have a corresponding project.

Shuman has discovered that students experience less science anxiety during the courses' guided design projects. They also report that the courses help them feel more confident in their ability to explain scientific phenomena and to use scientific information to justify their opinions. Shuman lists an additional benefit of guided design as the increased interactions between instructor and students. He notes that the instructor can meet more frequently with each of the project groups than he or she could with the individual members of a large lecture class.

Shuman states that guided design is ideal for general education, although he admits that it may not be appropriate in discipline areas in which students must acquire a certain amount of content in order to prepare for graduate school. He is interested in following up on student statements that as a result of physical science they are much more inclined to join citizen action groups and help improve their own communities. *P.B.*

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Syracuse University

Science Literacy Through General Education

Syracuse University's long standing commitment to science literacy was restated in 1979 when the College of Arts and Sciences initiated a new general education curriculum, the Liberal Arts Core. The new curriculum establishes a "numerical parity in the extensiveness of our distribution requirements among the humanities, social sciences, and natural science," says Gershon Vincow, dean of the college. In the fall 1982 semester Syracuse is expanding that commitment to technical literacy. This new focus "introduces students not only to the traditional sciences but also to the principles of engineering, aspects of technology and applied science, and analysis of socio-technological issues," according to a program description.

The Liberal Arts Core, which all undergraduates in the College of Arts and Sciences and the School of Public Communication must complete, was designed by faculty members to ensure coherence in course selection. In their first two years, students complete a four-course topical sequence, referred to as a "cluster" in each of the College's three divisions: Natural Science and Mathematics, Humanities, and the Social Sciences. Students also complete requirements in expository writing and either foreign language or mathematics.

Reducing Science Anxiety

In the Natural Sciences and Mathematics clusters students investigate "natural phenomena, including the development of predictive explanatory systems and . . . numerical and other abstract structures and relations," according to the course catalog. The clusters students choose include Biological Basis of Human Behavior; Scientific Methods: Uses and Abuses; Two Scientific Revolutions; Major Components of the Natural Sciences and Mathematics; Biology, Technology and Society; and Chemistry, Technology and Society. The college offered the last two clusters for the first time in fall 1982. Many of the students enrolled in clusters are freshman and sophomore nonscience majors; therefore, a central concern of the clusters' instructors is to develop students' confidence in their scientific abilities and an appreciation and curiosity about science.

Before students begin a science cluster they must pass an elementary algebra examination. "Science anxiety is related to mathematical manipulations," says Vincow. Giving students a choice of six clusters is also an attempt to reduce science anxiety, according to Vincow.

A two-semester laboratory/lecture series introduces the students to the natural science that the cluster will focus on. Almost every cluster offers a choice of introductory series and at least one is designed for nonscience majors. For example, students can begin the Two Scientific Revolutions cluster with either Physics for Non-Science Majors, General Physics, or General Physics for Science Majors. All students in that cluster would then go on to take two courses: Galileo and Concepts of Modern Physics.

A very popular introductory series option for four of the six clusters is General Biology, according to Vincow. Marvin Druger, professor of biology and developer of the course says, "I know many of the kids are fearful of science when they come in, so my first attempt is to convince them they can handle it." Druger employs weekly lectures, small group discussions, and Individualized Biology—an audio-tutorial series he developed. The tapes and workbook guide the students through the laboratory experiments, provide background information, and include quizzes students use to judge their progress before taking the exams. The audio-tutorial method (described in the Purdue University article) helps reduce students' science anxiety and enables Druger to cover more material and handle large numbers of students, he says. Unfortunately, Druger says, the tapes restrict experimental laboratory work and require more observational experiments.

Reducing science anxiety is one of Druger's major goals. During his 28 years of teaching biology he has developed a variety of techniques to handle the problem. He stresses that he refuses to water down the course, but, he says, "I design my first five units to be—not easy—but an overview of biology that's rather pleasant." As the material becomes harder students do not realize it, he says. He also includes jokes and music on the tapes and topics that are relevant to the students. Druger believes that showing the students how the course is designed to their best interests is crucial, as is explaining all aspects of the course: the grading system, when exams will be and what they will cover, and laboratory hours.

General Biology introduces a cluster developed specifi-

cally for nonscience majors: Science Methods: Uses and Abuses. After the introductory series, students take The Scientific Method, which presents case histories of scientific discoveries and focuses on the development of methodology and the role of mathematics in science, according to the course catalog. Science and Psuedo Science, the cluster's final course, attempts to answer such questions as "What is the proper datum of scientific inquiry? What are the requirements of a rational explanation? and reexamines "the nature of the scientific enterprise." Students discuss such popular topics as UFOs, ESP, astrology and the Bermuda Triangle.

Students have the option to design their own cluster by choosing four courses offered from the Major Components. For the introductory two-course series students may choose between Descriptive Astronomy, General Biology, Selected Topics in General Geology, and three chemistry, physics and mathematics courses of varying difficulty. One of the following two courses must include a course with laboratory, field, or computer work, such as A Programming Language in Mathematics: APL. Students must take courses from more than one department. The college recommends such strategies for developing a Major Components cluster as seeking an introduction to the aesthetics of science or linking the cluster to work in other divisions.

Technological Literacy

The clusters first offered in fall 1982, Biology, Technology and Society and Chemistry, Technology and Society, introduce students to technology and engineering studies. These clusters seek to ensure technological literacy "within a comprehensive framework including scientific literacy as well as an understanding of the impact of science and technology on society," Vincow says. The Biology, Technology and Society cluster courses include General Biology in the first two semesters, The Engineering Approach and Biological Technology in the third semester, and The Social Impact of Technology and Case Studies in Biological Technology in the fourth semester. Chemistry, Technology and Society differs only in that students have a choice of a general chemistry laboratory or an honors laboratory and they study the technology of chemistry instead of biology. As in all the Liberal Arts Core clusters, courses within these clusters complement each other; "topics covered in each course will be as much as possible alluded to in the other courses," says Vincow. Professors meet almost every other week to discuss how they are coordinating their materials and ideas. Because the courses are for general undergraduates at the freshman and sophomore level, much effort is made to match the courses to the students' backgrounds, Vincow says. The courses emphasize "general theories, basic ideas, concepts, definitions, and ways of thinking, and will attempt to extract from very complex fields of study those elements which are likely to be of enduring value and significance," Vincow says.

The three-credit technology component of both clusters, The Engineering Approach and Biological (or Chemical) Technology, is "in technology and not about technology," says Vincow. Students will "understand engineering as a fundamentally human enterprise . . . will understand the types of problems confronting engineers . . . gain a working knowledge of several concepts and principles of engineering (and) an appreciation of the limits of technology," according to the course description. In offering The Engineering Approach module the faculty is experimenting with the idea that there are fundamental engineering concepts which should be incorporated in a liberal arts education, Vincow says. The engineering module also stands out in importance, Vincow believes, because students are less likely to gain this information elsewhere in their studies.

The Engineering Approach begins with descriptions of selected major engineering developments such as computers, energy conversion, structures and dynamic machinery and ends with an examination of the limits and problems faced by engineers. Throughout the course the computer is the primary teaching tool. The Chemical Technology module begins with a survey of everyday chemical technologies related to energy, pollution, food, and health, and then discusses each topic in detail. Biological Technology applies "some of the ideas and approaches to problem solving learned in (The Engineering Approach) to genetic technology," the course description states.

The three-credit social dimensions component, The Social Impact of Technology and Case Studies in Biological (or Chemical) Technology, focuses on "the social dimensions surrounding the general problem of technological innovation, Vincow says. Some of the topics covered in the Social Impact module are moral views of science and technology, social history of society and technology, and attempts to improve decision making. The case studies of chemical technology for fall 1982 are battery and pharmaceutical technology—their social costs and benefits, interaction with other technologies, and regulations. The case studies for the Biology, Technology and Society cluster are "the ethical and legal considerations affecting public and personal judgments arising from advances in biotechnology" in the fields of cancer, genetics, and neo-natal health care for the severely handicapped, according to the course outline.

Vincow says that students generally react favorably to the clustered course approach. They accept the loss of flexibility and often opt for the more organized clusters. Crucial to the success of the clusters is identifying and engaging excellent faculty and working closely with them at all phases of the clusters' development, Vincow has discovered. *T.A.*

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University of Wisconsin-Madison

Western Culture and Contemporary Sciences

Students at the University of Wisconsin-Madison can satisfy much of their College of Letters and Science breadth requirements through Integrated Liberal Studies (ILS), a program that has its roots in Alexander Meiklejohn's 1927-32 Experimental College. The 12 interdisciplinary ILS

courses apply to distribution requirements in humanities, social studies, and natural science and provide an "alternative to scattered electives from over 100 departments," according to an ILS brochure.

The current goal of ILS, according to Michael Hinden, ILS chairperson, is the same as when a group of faculty members, including some who had worked with Meiklejohn, began the program in 1948. "We are committed to the concept of general education," says Hinden, who is also an associate professor of English. "ILS attempts to provide an overview of important themes, ideas, and developments in western civilization in order to give a sense of continuity to students who go on to choose a variety of majors."

As originally designed, the program of freshman and sophomore level courses required students to enroll in at least two ILS courses at the same time. In 1981 faculty members redesigned the program to match with the college's breadth requirements and to allow students to spread the coursework over their four years.

"The original designers wanted courses which integrated one with another so that students could make connections between the various subjects they were studying simultaneously," says Hinden. "We are still conscious of trying to make connections between the various subjects, and we encourage students to take more than one course at a time."

Students can complete the breadth requirements in one distribution area by taking all the ILS courses in that area. For example, the natural science breadth requirement for bachelor of arts majors is 12 credits, including three credits each in physical and biological sciences. The ILS courses Western Culture: Science, Technology, and Philosophy I and II carry natural science credit; Contemporary Physical Sciences and Contemporary Life Sciences carry physical science and biological science credit, respectively. Similarly, the four ILS humanities courses and four ILS social studies courses satisfy the humanities and social studies breadth requirements for bachelor of arts and bachelor of science students. Hinden notes that because the science breadth requirements for bachelor of science students is 16 credits, these students must complete additional science coursework outside the program.

ILS introduces students to the distribution areas in three two-course sets: Western Culture: Science, Technology, and Philosophy; Western Culture: Literature and the Arts; and Western Culture: Political, Economic and Social Thought. Faculty members arrange the interdisciplinary material in historical order, "tracing the achievements of western civilization from antiquity to the modern period," according to a program proposal.

Science, Technology, and Philosophy

"The traditional science course teaches the content of the discipline, but offers little about the nature of the scientific enterprise," says David Lindberg, professor of history of science and instructor of the first western culture science course. "My course's aim is to begin to impart a sophisticated understanding of this enterprise. Students may forget the content but if they know how science functions, they will have a permanent possession. Society needs people who understand what it means when a scientist claims to know something."

Lindberg begins his discussions of the scientific enterprise with an examination of early Greek cosmology and philosophy. He covers the historical and social context of scientific development through the seventeenth century with presentations on such topics as the Christian reception of pagan learning, the Copernican Revolution, magic and skepticism in the Renaissance, the study of human anatomy and physiology in the Renaissance, and Newton and the triumph of the modern world view.

"I connect the history of science with the history of philosophy," says Lindberg, "and show how science is always affected by the philosophical context and the world view."

The second western culture science course continues this emphasis by dividing the semester into three historical periods. The first focuses on the eighteenth century and the move from the scientific revolution to the Industrial Revolution with discussions on the scientific method, natural history, and the Enlightenment. In the second period students examine scientific and philosophical developments in the nineteenth century and learn about evolutionary biology and conservation of energy. The third period brings students up to the early twentieth century and the principle of relativity.

"In addition to the historical presentation of facts and ideas, these courses contain a significant component of actual problem-solving and mathematical exercises," says Hinden. In the first course, for example, students work with the mathematical formula associated with the development of the Copernican Theory and solve a problem in the same manner Galileo would approach the situation.

Lindberg finds that many of his students are terrified of science when they begin his class. He sympathizes with their science anxiety and believes it is based on their experiences in traditional science courses in which they learned to solve problems but did not understand what they were doing. He copes with their fears by explaining why they are doing something and by identifying when a concept is especially important for an understanding of a topic. Hinden believes the courses' interdisciplinary context and the classroom atmosphere also help reduce science anxiety.

Contemporary Sciences

Robert March, professor of physics, anticipates that by the time students enroll in his ILS course, Contemporary Physical Sciences, their previous exposure to science will have eliminated most of their science anxiety. He praises the western culture science instructors for preparing the nonscience majors for his course's discussions on such topics as relativity and the quantum theory, modern cosmology and astrophysics, and the quantum basis of chemistry and molecular biology.

Although March is teaching Contemporary Physical Sciences for the first time during the fall 1982 semester, he has taught similar courses in the physics department and during the ILS program revision. He finds the ILS students already understand the historical background of scientific developments in the twentieth century and are prepared to move into more in-depth discussions on relativity.

March weaves cultural information into his lectures. His presentations on relativity cover the culture of central Europe and point out how "the cultural values of the largely German clique of intellectuals led to the widespread attention given to Einstein and his work." His presentation on quantum theory includes the art and music of Germany and discussions on how the cultural fervency of the times

affected how the theory was stated.

"I emphasize science as a creative progression that is carried out by the people who are the products of their culture," says March. "The explanations scientists will accept and the phenomena they will consider important are very much culturally conditioned.

"I want to induce in my students a healthy skepticism toward cherished beliefs and principles by showing that in science, things that appear to be well-established can be overthrown," says March.

March also believes an understanding of contemporary science is important for the nonscience major. He says that a focus on strictly eighteenth and nineteenth century science is a disservice to someone who has to live in the twentieth century. "You have to understand the basis of contemporary science to understand why the government supports scientific research or what a scientist is trying to accomplish," says March.

The fourth ILS course, Contemporary Life Sciences, provides historical perspectives on the impact of human activity on the biosphere, according to March. Students examine the impact of agricultural methods and the Industrial Revolution and focus on such topics as the politics of hydraulic versus inundated agriculture, New World crops, and land ethics in the United States. Contemporary Life Sciences is the only ILS course which includes a laboratory; students attend sessions on plant parts, human evolution, meiosis, bread, herbs and spices, and New World crops.

March and Lindberg agree that the ILS courses do help students become more scientifically literate. Lindberg defines one aspect of science literacy as an understanding of how science functions and another as knowing some scientific content. Although he does not denigrate this second aspect, he believes the former is more important and is reached through the ILS courses.

Science literacy, to March, is a psychological state in which a person has no fear at looking into the scientific structure and arriving at opinions based on their understanding of science. "Five years from now our students should be able to read a newspaper article on some topic we discussed and say, 'Oh, yes, I remember that. So that's how much progress has been made since I last heard about that,'" says March.

Hinden emphasizes that students who enroll in the ILS humanities and social studies courses also learn about scientific developments. In keeping with the ILS philosophy of presenting the parallel developments in each of the different fields, instructors refer to scientific developments which bear on their subject matter. In Western Culture: Literature and Art, Hinden relates optics to the development of Renaissance art and mentions Darwin's theory of evolution and its effect on naturalism in the novel. The humanities course, The Interpretation of Technology, focuses on "how humanists have interpreted, feared, or welcomed scientific developments from the nineteenth century on," says Hinden.

The interdisciplinary nature of the program is of benefit to instructors as well as to students, according to March. "All the ILS faculty members hashed out the content of all the courses," he says. "The process was stimulating and educational."

One year into the new ILS program, Hinden says it is too early to tell how many students will complete part of their distribution requirements with ILS courses. In spring 1982 administrators approved an ILS certificate program which Hinden anticipates will help students achieve much of the integration available from the old ILS program. To earn a certificate students must complete 21 credits, including six credits in the intermediate level courses.

"ILS courses can counter the trend toward narrow professionalism on campus," says Hinden. "Science majors benefit from learning that history, political thought, literature, and art are more than fragmented electives and that culture is dependent on interrelated ideas. Nonscience majors benefit from seeing the impact of natural science on all branches of modern thought." *P.B.*

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Purdue University

Science as a Way of Life

By applying scientific methodology to both the design and structure of his freshman botany course, S.N. Postlethwait, professor of biology at Purdue University, has developed an instructional approach which he believes not only teaches students about botany but also presents a model for life. Postlethwait describes the science paradigm as "defining the problem as clearly as possible, gathering and evaluating relevant information, and making tentative conclusions concerning the problem." He first applied these procedures, familiar from his research on corn morphology, in 1961 as he studied how to improve instruction in Biology of Plants, a course required by students with varying degrees of interest and abilities.

Postlethwait determined that his students should practice this same science pattern in all facets of their coursework and integrated scientific methods into the procedures he uses for helping students learn about botany. In addition to employing the audio-tutorial system, which he designed and for which he is best known, Postlethwait divides Biology of Plants into more than 25 minicourses on such topics as seeds and germination, roots, and hormones and plant growth. Each minicourse follows the science paradigm by raising questions, providing activities for collecting data, and summarizing the major concerns. Postlethwait duplicates this pattern each time he introduces a new concept in a minicourse.

Although he began using the minicourse units after he designed the audio-tutorial system (A-T), Postlethwait discovered that they work well together. As implemented at Purdue, A-T is more than listening to a tape of the instructor; the system includes three major learning activities: general assembly sessions, independent study sessions, and teach-about-biology sessions.

Learning Activities

Students schedule independent study sessions (ISS) in

the course learning center at times convenient to them. Decorated with plants, photographs, and diagrams, the center, which Postlethwait calls a "fun, cheerful place," provides the necessary materials for minicourse activities. Students listen to tapes Postlethwait has prepared on the various minicourse objectives. He invites them to follow along in their study guides, perform experiments, and examine the course materials that teaching assistants have placed in the individual study booths.

Postlethwait strives for a personable approach on the tapes. "I psyche myself up for these," he says. "My task is to raise questions and issues. The tape allows me to visit with my students as they participate in a learning activity. In essence, I'm looking over their shoulders as they handle a plant or look through the microscope."

The exercises and study booth materials change from week to week depending upon the minicourse. For example, during the seed and germination minicourse each booth contains such items as an acorn, bean and corn seeds, an iodine solution, and a microscope. A central table holds larger specimens. Students test for starch in the bean seed and examine the germination patterns of various plants. Minicourse objectives include the ability to identify the parts of the seeds, name environmental factors that influence germination, and describe how delayed seed germination benefits certain plant species.

While the ISS provides a simulated one-to-one interaction with the instructor, the general assembly sessions gather together each semester's more than 300 Biology of Plants students in weekly one hour meetings to see the face behind the voice. For the first 30 minutes students attend lectures, movies, or multi-image presentations. During the remaining time they use the science model to prepare written summaries of the presentation.

The science paradigm also plays a central role in the teach-about-biology sessions. Scheduled once a week, these sessions require students to make oral presentations on the minicourse objectives. Eight to ten students and a teaching assistant sit around a lazy susan table which holds materials used in the current minicourse. The assistant randomly selects students to identify an item, describe how it relates to an objective and teach about it. This "intellectual roulette," as Postlethwait calls it, forces students to prepare presentations on all the minicourses' objectives. Students also prepare written summaries, identical in format to those written in the general assembly, on journal articles.

In all three session Postlethwait says he gives "critical attention to structuring tests and learning experiences so a reasonable 'attention to the task' will result in student success." He says, "By making students successful learners I am able to handle their science anxiety. When students recognize they do know and understand a new phenomenon, they are encouraged and excited about their progress."

The majority of Postlethwait's students are agricultural and pharmacy majors who are required to complete both Biology of Plants and Biology of Animals. The latter course also employs the A-T system. Other Purdue students can choose one or both of the courses to satisfy general education requirements.

Postlethwait believes his students learn more than introductory biology. "Science is important not only for those people who work in a laboratory but as a way of life for all of us," he says. "My course provides practice in following the science pattern."

The course also develops skills which are attractive to employers, according to Postlethwait. "Employers are looking for responsible people who can make an oral presentation to a boss or committee and write a succinct report," he says. "My students have more experience in organization, preparation, and presentation than they would have in a normal public speaking course."

Postlethwait believes "a good teacher is a good learner." He says that the "integrated learning experiences" that comprise his course are continuously evolving, often with suggestions from teaching assistants and students. For example, he notes that the addition of microcomputers could increase the course's capacity for interactive learning.

Postlethwait concludes that the science paradigm is a successful instructional approach. He says: "A teacher should model the same openness to new information, new ways, and new ideas that teachers expect of students." *P.B.*

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Iona College

Energy, Environment, and Health

Following a tradition that is almost as old as the college itself, science faculty members at the 42-year-old Iona College are developing a set of science courses for nonscience majors that will satisfy the new core curriculum's science and technology requirements. In the past, these students chose their six science credits from a variety of lecture-only science courses designed to introduce nonscience majors to the natural sciences, according to James Murphy, professor of physics. Faculty members are currently designing three four-module interdisciplinary sequences for nonscience majors. As part of Iona's new core curriculum, the nonscience majors, who comprise 90 percent of the student population, will choose one sequence in energy, environment, or health.

The new core curriculum, which the Academic Senate approved in May 1982, includes coursework in humanities, social sciences, natural and symbolic languages, and communication skills, in addition to the science and technology requirement. Administrators plan to implement the new core curriculum during the 1983-84 academic year.

As with the other core areas, faculty members prepared objectives which must be met by the science sequences. According to the revised core curriculum proposal, the science and technology objectives include providing students with "an understanding of the nature of scientific knowledge and the appropriate application of scientific concepts, principles, laws, and theories;" the ability to "utilize the processes of science in solving problems, making decisions, and furthering his or her understanding of nature and technology;" and "an understanding and appreciation of the joint enterprises of science and technology and their interrelationships with each other and other aspects of society."

While other faculty members are creating programs to satisfy their area's new objectives, the science faculty members are testing and refining the module sequences that they began developing in 1979, according to Murphy. At that time there were two major stimuli in the faculty members' drive to create a science program which, in Murphy's words, would "prepare students, both as professionals and as conscientious citizens, to deal with a future whose opportunities and problems will be strongly coupled to scientific technology." Murphy reports that their first stimulus was the science faculty members' realization that they could be doing more for their students and that the necessity for a scientifically literate citizenry in the future would demand that they do more. The second stimulus came from the president who asked the science faculty members for their ideas in developing a program of study for the Iona student and who encouraged their discussions and planning.

Murphy, as director of academic development in science and technology, plans and coordinates the program that culminated from the science faculty members' discussions and proposals. In addition to the goal of scientific and technological literacy, he has responsibility for directing efforts to strengthen the science major programs and community service.

Guiding Postulates

The thematic sequences have undergone several revisions, according to Murphy. He notes that in all stages faculty members, representing the departments of biology, chemistry, computer and information science, mathematics, physics, and psychology, have organized the curriculum according to five postulates: learning requires student interest, students learn from hands-on experience, both science and technology must be confronted in a program attempting to educate students for informed citizenship in the future, computers are an essential component of scientific and technological literacy, and the acquisition of the reasoning modes employed by scientists and engineers is a developmental process that takes time.

In elaborating on the first postulate, Murphy states that the module designers "wanted students to see the scientific and technological concepts in a context they can relate to." He notes that the themes of energy, environment, and health also are broad enough "so that our faculty can work under them in areas in which they are skilled and in which they feel they have something to contribute."

In following the second postulate, course designers integrated hands-on experience, including laboratory work, reasoning exercises, and nonclassroom activities, in all of the modules. In addition to the traditional science focus, the faculty members included technological perspectives in the courses with discussions on the problem-analysis and decision-making procedures in the technology appropriate to the sequence theme. Murphy notes that his science colleagues found materials developed by persons active in such organizations as the Council for the Understanding of Technology in Human Affairs (CUTHA) useful in defining the modules' technology component.

The Science Development Committee, which developed the science and technology proposal, originally followed the fourth postulate, which emphasizes the importance of computer literacy, by designing a parallel sequence on computers that students would follow as they pursued their thematic sequence. Faculty members deleted the sequence when computer literacy became part of the new core curriculum under the natural and symbolic languages requirement. Students must demonstrate computer literacy through completion of one computer science course or through a competency test which faculty members plan to develop. Murphy emphasizes that computer exercises in modeling and simulation continue to be integrated into the modules.

The committee acknowledged the final postulate, the acquisition of reasoning modes is a developmental process, by increasing the amount of time students will spend completing science requirements. While the old science requirement could be completed in two semesters, the new program requires four semesters. Because each module in the four-module sequences carries one-and-a-half credits, the number of required credits remains the same as in the old program.

Three Thematic Areas

Faculty members present the themes of energy, health, and environment by following the same content pattern in each of the sequences. The first module in a sequence covers basic science principles and introduces the sequence theme. The second and third modules deal with current topics of concern in the theme area. The last module is "future oriented and focuses on the predictive powers of science and the methodology of technology assessment," says Murphy.

The environment sequence's first module is Matter, Energy, Life, and Fundamentals of Ecology. This course introduces ecological principles and includes discussions on the experimental method, types of energy, probability and statistics, and ecosystems. Students complete such activities as designing a primitive solar collector, developing and recognizing patterns of chemical reactions, and locating and describing a small ecosystem. The first modules in the health and energy sequences also begin with an examination of "the scientific concepts underlying matter, energy, and life;" the introductory health module also covers biochemistry and nutrition, while the energy module focuses on energy transformation.

With an understanding of the underlying principles in each theme area, students are able to address the current problems in that area in the second and third modules. The environment modules are Uses and Abuses of Resources and Controlling Wastes.

"The difference between the second and third modules will normally be the math and science preparation and the level of computer and project work we expect of the students," says Murphy. Uses and Abuses of Resources deals with the resources of land, water, and air in discussions on the carbon dioxide build up in the atmosphere, water conservation, and acid precipitation. The third environment module will concentrate on the local solid waste problem, according to Murphy.

"We will look at the political process in the recent referendum for a municipal solid waste resource recovery facility, examine its design, and read the environmental impact report," says Murphy. Other topics in the third environment module include the waste water treatment plant being constructed in New York City along the Hudson River, air borne industrial wastes, and radioactive waste.

In the health sequence the second and third modules will

examine such concerns as cardiovascular fitness, disease states, and the psychological and physiological factors that influence the function of the human brain. Renewable Energy Resources and Electricity and Electrical Technology, the second and third energy modules, focus on extracting energy from other sources, production and distribution of energy, and "the flow of electricity in an industrial society . . . with emphasis on fuels, production processes, efficiency, impact and safety," according to a course description.

Similar to the first module in each sequence, the fourth module also will provide students with common experiences, according to Murphy. Each module examines technology assessment in its theme area and allows students to test decision-making models. Faculty members will present case studies which have involved forecasting in such areas as air pollution control, energy policies, and food additives and use the United States Office of Technology Assessment summary reports as texts. Each fourth module also will include value considerations. Murphy speculates that Assessing the Environmental Future will focus on radioactive waste and the difficulty of making regulatory policy with uncertain data.

The third and fourth modules in each sequence are either not complete or have not been tested, says Murphy. In evaluations of the sequences' first two modules, which have been tested, students have commented that they like the thematic approach.

Murphy notes that some of the students experience science anxiety. He deals with this by being as open as possible about the nature of the courses. By using the activities planned for early in the semester as diagnostic tools, he can identify which students may need additional assistance.

Murphy believes that the new requirements will help all Iona students develop the skills that they will need "to deal in a problem-solving way not only with those issues that surface today but also with those which will appear ten or twenty years from now when they will be in positions of responsibility which require them to act."

In addition to the requirements for nonscience majors, science majors also will have to demonstrate scientific and technological literacy, according to Murphy. He anticipates that faculty members will design a course in technology and problem solving for science majors. Science and technology also is one of the themes presented in the Western Civilization course in the new humanities core curriculum.

Murphy classifies Iona's efforts as a "homegrown approach." He notes that faculty members developed the science and technology requirement for the students they have come to recognize at Iona and to build on their own strengths and interests. *P.B.*

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Additional Programs

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Science in the Core Curriculum—During fall 1981 Brooklyn College initiated its Core Curriculum, a set of ten required courses developed by faculty members. The science core consists of four seven-week laboratory/lecture courses designed for nonscience majors. Core courses cover the basic concepts of chemistry, biology, physics, and geology and their implications in modern life. The chemistry and physics courses are prerequisites to the geology and biology courses. The chemistry course incorporates the "nontraditional interdisciplinary teaching methods" of the course's instructor, Dominick Labianca, associate professor of chemistry and William Reeves, associate professor of English. During the course's first five weeks students learn basic concepts. In the last two weeks Labianca uses literature to help illustrate the chemical principles. For example, to give students a handle on the chemical properties of drugs, Labianca will explain them in scientific terms in the first part of the course. During the last two weeks Reeves will, as a guest instructor, lead a discussion on drugs in detective fiction. Environmental pollution is another topic well suited to this approach, Reeves says. He portrays the human consequences of pollution with passages from Blake's "Songs of Innocence and Experience" or Dickens' *Oliver Twist*. When "chemical principles that are simply formulas on the board" are seen in human situations students interest and therefore memory for the material increases, Reeves says. Their methods are not fool proof, Labianca recognizes, and he stresses the need for models and demonstrations for the topics that do not link well with literature. The physics course, Concepts of Space and Time, takes a historical approach to science literacy by examining the "evolution of our concepts of space and time from the observations and inferences of the Greeks to the exotic notions of contemporary physics," according to the course catalog. The biology course, Life: A Modern Perspective, seeks primarily to elicit an appreciation of the unique qualities of life. The only course focusing on a specific concept in science is geology. It examines plate tectonics in relation with evolution, energy, and mineral resources. *T.A.*
Dominick Labianca, Associate Professor of Chemistry

Columbia College, Columbia University, New York, NY 10027

The Theory and Practice of Science—Three faculty members from the departments of biological sciences, nuclear physics, and computer sciences have designed a two-semester science course for nonscience majors, that has the potential of becoming the third branch in Columbia College's traditional core curriculum. Students at this men's liberal arts college must complete a two-semester introductory sequence from one of the science departments. The year-old Theory and Practice of Science provides an alternative sequence and is patterned after the interdisciplinary core courses Humanities and Contemporary Civilizations. These required four-semester humanities and two-semester social sciences courses, begun in 1939 and 1919 respectively, feature small seminar classes which follow a prescribed curriculum of primary readings, lectures, and discussions. Using this core model, Robert E. Pollack, dean of Columbia College and professor of biological sciences, helped develop the new sequence which attempts to "introduce . . . the ways in which the sciences arrive at their pictures of the underlying mechanisms of the physical world . . . (and) examine how scientific models and theories are invented and how they come to be accepted, verified—and rejected," according to the course description. Pollack believes that science, similar to other liberal arts, has its own set of intellectual tools and is an open-ended creative discipline. He reinforces this notion by asking students to treat data in the same manner he handles it in his own laboratory. "We worry about whether it's accurate and statistically significant and whether the experimental design really supports the conclusion," says Pollack. His students study mathematical patterns and modeling techniques and conclude the first semester with case studies on nuclear fission and the discrete nature of the electron charge. The second term includes discussions on probabalistic models and statistical inferences and focuses on genetics and recombinant DNA technology. Pollack prefers the case study approach over laboratory experiments which he says can wrongly convince students that there is only one correct answer. He emphasizes that his course is more than class discussions; students complete exercises and quizzes and prepare essays on the

readings in scientific literature. During the 1982-83 academic year Pollack plans to invite scientists to present their work in campus lectures. "I will judge my success by how much students trained in my course understand the lectures," he says. Pollack admits that the new course may never become a core requirement. The instructors are preparing a textbook for completion by 1985 and will be pleased if the course becomes a permanent alternative science sequence. Although the course is seeking funds from the Alfred P. Sloan Foundation for the continuation of the course after next year, Pollack stresses that the course was developed with a private donor's gift from the president's office. "This is an example of private philanthropy being used as seed money," he says. "You don't need 20 faculty members and 20 million dollars to design a course such as ours." *PB*

Robert E. Pollack, Dean of Columbia College

George Washington University, Washington, DC 20052

Interdisciplinary Science—Recognizing that many nonscientists in decision-making positions find themselves inadequately prepared to evaluate scientific data, faculty members at George Washington University (GW) designed a graduate-level interdisciplinary course on the nature of science. First offered during the 1981-82 academic year, the course follows a GW tradition of responding to professionals' needs by creating interdisciplinary programs which address their concerns, such as the graduate programs in legislative affairs and natural resources and environmental studies. Titled Interdisciplinary Science, the course is the creation of a biologist, physicist, and chemist. With funds from the Exxon Education Foundation, the instructors designed a two-semester, twice-a-week sequence which focuses on the nature of the physical universe and how each of their disciplines relates to its complex hierarchy. The instructors assume that their students understand basic algebra but have little background in science. They divide the course into four main topics: purpose and methods of science, structure and properties of matter, chemical transformation of matter, and complexity beyond macromolecular. Students begin with discussions on probability, statistics, and the place of observation and experimentation and later examine such topics as the laws of nature, nuclear and atomic structures, states of matter, chemical reactions, and life structures and processes. In the course's original design, each class session featured one primary lecture and two secondary lectures; for example, the chemist discussed liquid states, solids, and phase dispersions after which the physicist and biologist described the nature of molecular forces and gas transport in animals, respectively. The instructors modified this structure to include one primary lecture and informal discussions in place of the secondary lectures. Typed copies of all presentations serve as the course text. Henry Merchant, associate professor of biology, finds it rewarding to watch students understand something for the first time and grasp the interactions between the three disciplines. He says his students, who do not have careers in science but whose positions force them to deal with science and science information, feel that the course does serve their needs. *PB*

Henry Merchant, Associate Professor of Biology

Los Medanos College, Pittsburg, CA 94565

General Education Science Courses—In the nine years since the college's establishment, Los Medanos College (LMC) administrators and faculty members have strived to develop a general education program that produces responsible citizens. Biological and physical sciences are an integral part of the community college's three-tiered approach to generalized learning, according to Stanley H. Chin, dean of natural science and related occupations. The program's first tier consists of one course selected from each of five areas: language arts, behavioral science, biological science, humanistic studies, and physical science; and two courses from the social sciences. An LMC committee developed eight criteria that must be met before courses can receive the general education designation. They are intradisciplinary concepts and principles, modes of inquiry, aesthetics of knowledge, implications of knowledge, reading and writing in the learning process, effective thinking, creativity, and pluralism. For example, the intradisciplinary concepts for all general education biological science courses include evolution, homeostasis, life cycles, and energy relationships. The scientific process of gathering information, classifying the information, correlating the information into patterns, and interpreting the patterns is the mode of inquiry for all natural science courses. Chin notes that all science courses include traditional laboratories, audio-tutorial laboratories (described in the Purdue University article), and/or field experiences to help satisfy the mode of inquiry, critical thinking, and aesthetics of knowledge criteria. Tier one biological science courses include Biology and Health Principles of Biology, and Ecology; physical science courses include General College Chemistry, Introduction to Astronomy, and General College Physics. LMC's second tier courses are Social Order and Institutions and An Ethical Inquiry into Societal Issues, an interdisciplinary course which focuses on such topics as the population explosion, sexual and racial equality, and nuclear war. For the third tier requirement students enroll in one of the tier one disciplines' ethical inquiry courses. While the second tier ethical inquiry course examines five different issues, each third tier course focuses on one. In the biological science course on control of life and death, students discuss biological engineering, health care delivery, and prolongation of life. Other science inquiry courses examine energy and science and human values. Students complete a self-directed study in their third tier course. Taught in the tier two ethical inquiry course, this process includes the identification of the ethical issues associated with a social problem, exploration of the topic through library research and interviews with local experts, and analysis of the findings in a written or oral presentation. Chin admits that many students are threatened by the science requirements. Instructors combat this anxiety by not including a heavy mathematics emphasis or a great deal of memorization in the first few weeks of class. In addition, says Chin, the mode of inquiry demonstrates that there are no right answers to science problems, which alleviates some of the students' anxiety, and offers "a generalized problem-solving process that they can use in their everyday life." This process also reemphasizes LMC's goal of educating citizens who can respond to societal concerns. *PB*

Stanley H. Chin, Dean of Natural Science and Related Occupations

Pennsylvania State University, University Park, PA 16802

Science, Technology, and Society—The philosophy behind Pennsylvania State University's Science, Technology and Society (STS) Program is that "science for all" is only effective when it is taught *in relation* to something else in life," says Rustom Roy, STS chairperson. Roy notes that the standard requirement of three introductory science courses has failed to produce scientifically literate citizens because students do not learn how to integrate the materials or how to relate it to their daily existence. In the 11-year-old STS program, juniors, seniors, and graduate students examine the relationships between science and technology and society in such courses as World Food Problems, Energy and Modern Society, and Medical Ethics. Roy emphasizes that by concentrating first on a topic's relationship to technology, instructors are able to stir students' curiosity in a subject. "A nuclear power plant is the place at which individual contact with science and technology is made," says Roy, "not at nuclear fission or with chemical reactions." In addition to the initial technological focus, most STS courses are team taught by instructors representing the sciences or engineering and humanities or social sciences. "STS teaches students to bring viewpoints from several perspectives to bear on a subject," says Roy. For example, the Radiation, Reactors, and Society instructors try to present both the positive and negative effects of nuclear power. Students can earn an STS certificate by completing at least four STS courses and an additional four courses, in STS or other departments, which relate to the program theme. In summarizing how to increase students' understanding of science, Roy says, "People will be interested in science if they can make contact first with its application. They want to know why nuclear dumping is bad. Experience is a great motivator." *PB*

Rustom Roy, STS Chairperson

Saint Joseph College, West Hartford, CT 06117

Environmental Science—At St. Joseph College, a liberal arts college for women, students complete eight credit hours in the Natural Science and Mathematics Division as part of the college's general education requirement. Humanities and social science majors often opt for Environmental Science, a course developed eight years ago specifically for nonscience majors. Each year a few nonscience majors from the course will, in the following semester, complete an independent study of a topic they have become particularly interested in. This combination of options "has been extremely valuable in developing scientific literacy," says Harold McKone, chairperson of the chemistry department and developer of the course. The Environmental Science course topic changes depending on the latest crisis, McKone says, and has included hazardous wastes, energy, and Three Mile Island. But the philosophical goal remains the same: "the student becomes aware of modern scientific terminology, of scientific reasoning and of the need to understand the problems of a modern technological world from a scientific viewpoint," McKone says. The course examines the use and

abuse of the earth's resources, interaction between living things and the environment, and the effects of modern technology on humans, according to the course description. Along with three hours of lecture, the course includes weekly laboratory or field experience. The students visit local industries, power plants, and hospitals. McKone tries to choose places where college alumnae are in responsible positions. To help alleviate science anxiety in all students the administrators hire faculty members who are sensitive to the problem, says Claire Markham, graduate dean and professor of chemistry. "We make it a point that the faculty we hire are top research faculty. But we also really want to get people who can reach nonscience majors and help those students realize (the required courses) are not just an academic exercise they have to go through," Markham says. *T.A.*

Claire Markham, Graduate Dean and Professor of Chemistry

Resources

Several recent issues of *Forum* may be of interest to persons interested in reexamining their school's science program. They are "Integrating Sciences and Humanities (May 1979)," "Innovations in Science Teaching (February 1980)," "Technological Literacy and the Liberal Arts (December 1980)," and "Computer-Based Learning (May 1981)." Single copies of each issue are available for $2. For information on the content of these issues please contact Tina Adler in the *Forum* office.

American Association for the Advancement of Science, 1776 Massachusetts Ave. NW, Washington, DC 20036. 202/467-4400. William Carey, Executive Officer.

Formed in 1848, AAAS encompasses 21 sections which embrace the principal fields of science. It has 140,000 individual members and approximately 286 affiliated scientific and engineering societies and academies of science. Publications are *Science*, a weekly magazine, which includes scientific papers, science policy reports, and research news, and *Science 82*, a monthly magazine for the popular audience which strives to "contribute to the public understanding of science and technology." Other publications include *Education in the Sciences*, which outlines AAAS' recommendations for modifying current educational policies and practices, and *Science, The Media, and the Public: Selected Annotated Bibliographies*, which provides annotated entries on publications and radio and television series focusing on science.

American Association for the Advancement of Science. *EVIST Resource Directory*. Washington, DC: AAAS, 1978.

This guide, funded by grants from the National Science Foundation, lists approximately 120 programs and 900 courses currently in existence which are oriented toward ethics and values in science and technology (EVIST). General categories include science/technology and society, chemistry and society, physics and society, and the history and philosophy of science and technology. Over 500 institutions are represented.

American Association of Physics Teachers. *Guide to Innovations in Physics Teaching*. New York: AAPT, 1974.

This three-volume set focuses on nontraditional formats, courses for nonscientists, and courses for physics majors. Each volume includes brief descriptions, intended audience, and contact persons of a wide range of physics activities. The volume on courses for nonscientists covers physics in the humanities and physics and society courses and pedagogical innovations.

Annett, Clarence H. "Experience with a professionally oriented astronomy laboratory for nonscience majors." *American Journal of Physics* 48 (Feb. 1980): 134-137.

Annett describes the goals and content of an introductory astronomy course's adjunct laboratory for nonscience majors. By combining evening observation sessions with challenging indoor laboratory work, he was able to provide students with an understanding of professional astronomers' activities, including the "desk work" necessary for astronomical research. He outlines 14 laboratory exercises, such as plotting the paths of planets and comets, locating objects from coordinates, and applying the tuning fork classification of galaxy systems. Annett recently taught an astronomy workshop for parents and children, and welcomes correspondence from others developing astronomy courses for nonscience majors. His address is 4417 Minnie St., Kansas City, KS 66103.

BioScience

The official publication of the American Institute of Biological Sciences, this monthly magazine carries state-of-the-art reports, book reviews, news, and condensations of recently published research. The October issue examines such areas of concern in biology education as theory, structure, teaching, and learning. Yearly subscriptions are $43. Kathye Pettebone-Long, Managing Editor, *BioScience*, AIBS, 1401 Wilson Blvd., Arlington, VA 22209.

Brawer, Florence B., ed. *Teaching the Sciences*. New Directions for Community Colleges, no. 31. San Francisco: Jossey-Bass Inc., Publishers, 1980.

This book focuses on how various instructional strategies can be adapted to science teaching. Bette Slutsky describes her biology course on women's sexuality and advocates the use of general education courses which relate directly to students' interests and concerns. Fred A. Thompson presents a systematic approach to individualized learning, which includes employing quizzes as diagnostic tools, tailoring assignments to individual needs, and specifying the learning objectives for each course unit. Other chapters focus on individualized mathematics instruction, "the psychology of teaching psychology," and resources in science education.

Bulletin of Science, Technology & Society

Designed for persons interested in the interactions between science, technology, and society, *BSTS* contains articles, news items, and freely reproducible modular teaching materials, syllabi, and course outlines. One-year institutional subscriptions are $75; the rate for individuals whose library subscribes is $30. Rustom Roy, Editor-in-Chief, *BSTS*, Materials Research Laboratory, Pennsylvania State University, University Park, PA 16802. Subscription address: Pergamon Press, Inc., Fairview Park, Elmsford, NY 10532.

Carlson, Elof Axel. "Biology for Nonmajors." In *The Modern American College*, edited by Arthur W. Chickering, pp. 440-452. San Francisco: Jossey-Bass Inc., Publishers, 1981.

Carlson believes biology education is not adequately preparing students for decision-making in their personal lives and as citizens and professionals. He advocates that courses for nonscience majors present topics in the context of students' lives and experiences; topics which lend themselves to this type of examination include birth control, carcinogenesis, racism, germ warfare, and radiation hazards. He believes the model of the scholar-teacher is especially important for effective instruction in large lecture introductory courses.

Center for Guided Design, Engineering Sciences Building, West Virginia University, Morgantown, WV 26506. 304/293-3445, Charles Wales, Director.

Funded by the Exxon Education Foundation, the center serves as an information resource center on applications of guided design (described in the West Virginia University article). Center staff members conduct regional and in-house workshops; Wales invites applications from colleges and universities interested in hosting workshops. The center publishes a newsletter and directory of persons involved in guided design.

Consortium for Mathematics and its Applications, 55 Chapel St., Newton, MA 02160. 617/969-7100. Solomon A. Garfunkel, Executive Director.

COMAP is a year-old membership organization "devoted to dissemination of modulatory materials on applied mathematics," according to Lynn Arthur Steer, council chairperson. The consortium distributes information on instructional modules which are designed to apply mathematics to such fields as earth science, American politics, and psychology.

Council for the Understanding of Technology in Human Affairs, Massachusetts Institute of Technology, Room E40-481, Cambridge, MA

02139. 617/253-8074. John Truxal, Executive Director. Edith Ruina, Program Coordinator.

Established in 1979, CUTHA provides an organizational focus for educators, policy makers, and industrial organizations interested in collaborating in developing strategies and tactics for expanding technological literacy. Activities include dissemination of information and publication of *The Weaver*, a biannual newsletter which includes descriptions of college activities, discussions of the goals of technological literacy, information on specific technological issues, and recommended books and articles.

Dean, Donald S. "The Nonmajor: A Challenge and Responsibility." *The American Biology Teacher*. December 1978, pp. 564-565.

Dean asserts that biology faculty should be expecting to teach more nonscience majors, due to trends in core curriculum requirements, and less science majors, as the job market for scientists becomes tighter. His ten commandments for teaching science to nonscience majors include remembering that nonscience majors may be as able as majors, their abilities will be more varied, and they deserve quality faculty and topics relevant to their interests. Also, the course should not be a sociology course in disguise or a survey course of biology.

European Journal of Science Education.

This three-year-old quarterly journal on science education aims "to describe and assess the specifically European contribution to educational theory and practice and to exchange opinions and information," according to Richard Steele, of the editorial offices of Taylor & Francis Ltd., the publisher. A recent issue (January-March 1982) included articles on science as a component of general education and the use of science case histories to aid in students' understanding of science. Richard Kempa, University of Keele, UK and Karl Frey, Institute for Science Education, Kiel, FR Germany, Editors. Individual subscriptions are $42.50 and should be paid to Account 04 810 879 Bankers Trust Company, P.O. Box 9137, Church Street Station, New York, NY 10049.

Factor, Lance and Kooser, Robert. *Value Presuppositions in Science Textbooks: A Critical Bibliography*. Galesburg, IL: Knox College, 1981.

This study of science textbooks frequently used in chemistry courses for nonscience majors claims many carry moral messages or normative prejudices, although there is a remarkable uniformity in the factual content. The authors examined nearly all the chemistry texts on the market during the 1979-80 academic year. They categorize the books as science and society texts, skills and drills, textbooks for allied health and related fields, and physics textbooks. General statements about these types of texts are followed by discussions of individual books and how they present the scientific method and history and technology. The paper ends with charts showing the amount of space devoted to such subjects as pollution, drugs, and nuclear science.

Haight, G.P. "Balancing Chemistry's Priorities." *Change: The Magazine of Higher Learning*. Vol. 8, No. 2 (March 1976), pp. 4-5.

Included in a six-part series entitled "Report on Teaching," this short introductory essay briefly summarizes four problems currently facing chemistry professors: what materials are appropriate for an introductory course, how to deal with a diverse student body, how to incorporate modern technical aids into the chemistry curriculum, and ways to train students to think analytically. Other articles in this issue deal with such topics in chemistry education as the use of computers in teaching, chemistry curricula in nontraditional settings, and teaching environmental chemistry. Subsequent *Change* issues which include similar reports on teaching sciences are:

Biology, "Report on Teaching, 2." Vol. 8, No. 6 (July 1976)
Mathematics, "Report on Teaching, 3." Vol. 9, No. 1 (January 1977)
Physics, "Report on Teaching, 5." Vol. 10, No. 1 (January 1978)
Interdisciplinary Studies, "Report on Teaching, 6." Vol. 10, No. 7 (August 1978)

Helms, Susan, and Montague, Earl J. "A Study of College Nonscience Majors' Expectations of the Scientific Enterprise." *Journal of Research in Science Teaching* 17 (1980): 553-558.

The article describes the methodology and conclusions of the authors' correlational study assessing nonscience majors expectations of what science can accomplish. The authors surveyed 1,014 students enrolled in chemistry courses for nonscience majors in Texas colleges and universities. The study's goal was to determine which of the students' academic and nonacademic experiences may contribute to developing realistic expectations of science. The study suggests an emphasis on history of science, scientific methodology, and practical uses of science in society may be less helpful in developing realistic expectations than an emphasis on basic scientific concepts and principles.

Hurd, Paul De Hart. "Falling Behind in Math and Science." *The Washington Post*. May 16, 1982.

In comparing U.S. elementary and high school science and mathematics education with that of other countries, Hurd notes that our students spend less time in school, receive science and mathematics instruction through grade six from their regular instructor rather than from a specially trained instructor, and spend two-thirds less time on science and mathematics subjects. Although he notes that American educators should not necessarily copy other nations' approaches, he emphasizes that a commitment to precollege science and mathematics education is recognized by other countries as a means for "encouraging a large percentage of students to pursue careers in science, mathematics, and engineering, and in generating a supportive citizenry for scientific endeavors."

The Journal of Computers in Mathematics and Science Teaching.

Published by the Association for Computers in Mathematics and Science Teaching, this quarterly journal details experiences and information in college and secondary and elementary school level mathematics/science instruction with computers. Of special interest is the annotated bibliography on computer use in specific subjects. ACMST membership dues are $15 and include a journal subscription. Gary H. Marks, Editor, *The Journal of Computers in Mathematics and Science Teaching*, P.O. Box 4455, Austin, TX 78765.

National Council of Teachers of Mathematics, 1906 Association Drive, Reston, VA 22091. 703/620-9840. James D. Gates, Executive Director.

The purpose of the 62-year-old NCTM is "to assist in promoting the interests of mathematics . . . and to vitalize and coordinate the work of local organizations of teachers of mathematics." Periodicals include the monthly *Arithmetic Teacher*, designed for preservice and inservice elementary school teachers; the monthly *Mathematics Teacher*, which emphasizes practical advice for secondary and community college instructors; and the five-times-a-year *Journal for Research in Mathematics Education*. Other publications of interest include *An Agenda for Action: Recommendations for School Mathematics of the 1980s* (1980), which lists such recommendations as "problem solving must be the focus of school mathematics in the 1980s," "mathematics programs must take full advantage of the power of calculators and computers at all grade levels," and "more mathematics study must be required for all students," and *Priorities in School Mathematics* (1981) which reports on nationwide surveys on possible mathematics curriculum changes.

National Research Council. *Science for Nonspecialists: The College Years*. Washington, DC: National Academy Press, 1982.

This report by the Council's Committee on the Federal Role in College Science Education of Non-Specialists calls for colleges and universities to prepare all students to deal with science and technology in order that they may become more knowledgeable and effective as citizens, opinion leaders, and professionals. Recommendations include the requirement for nonscience majors of two one-year courses selected from the biological and physical sciences and mathematics, the extension of nontraditional instructional media to science teaching, and the creation by the federal government of a National Science Foundation program to oversee improvement in science and technology education for nonscience majors.

National Science Foundation. *The Five-Year Outlook on Science and Technology 1981*. Washington, DC: National Science Foundation, 1982.

According to its introduction, *The Five-Year Outlook* is "based on the premise that the unmistakable influence of science and technology on contemporary trends and outcomes is unlikely to abate." The report discusses the various national issues that do or will depend on a high level of science and technology within the next five years. These areas include national security, health, space, energy, natural resources, environment, transportation, agriculture, and education. *The Five-Year Outlook* also describes some of the problems, opportunities, and constraints that may arise as a result of scientific and technological activities. The chapter on education discusses, among other topics, "The Problem of Transferring Technology Into Teaching Situations," "Providing Adequate Education in Science and Technology," and "Explaining Public Awareness and Understanding of Science and Technology."

National Science Teachers Association. *Science Looks at Itself*. New York: Charles Scribner's Sons, 1970.

Essays in this collection, published on the occasion of NSTA's 25th anniversary, concern specific insights that science can bring to consideration of contemporary and future social problems. Of particular interest is the final selection, Philip Ritterbush's "The Now Generation, Science Teaching, and The Future," which promotes science education as a means of acquainting future citizens with science as a primary cause of social change.

Postlethwait, S.N.; Novak, J.; and Murray, H.T. *The Audio-Tutorial Approach to Learning*. Minneapolis, MN: Burgess Publishing Co., 1972.

The authors provide a detailed examination of the audio-tutorial approach described in the Purdue University article. The book includes the history and theory behind this approach, photographs and descriptions of the physical facilities most useful in adopting the audio-tutorial methods, and discussions of the minicourse concept.

Science Activities

This quarterly publication is directed at preservice and inservice elementary, junior, and high school teachers looking for assistance in teaching science. Issues include descriptive articles on classroom activities, book reviews, and new products. Special issues have examined microcomputers, earth science, outdoor education, and astronomy. Subscription rates are $20 for the remainder of 1982 and $25 for 1983. Jane Powers Weldon, Managing Editor, *Science Activities*, 4000 Albemarle St., NW, Washington, DC 20016.

Science Education

Published five times a year, this journal includes sections on science curricula and instructional programs, the psychological aspects of the learning of science, international science education, and current educational, social, or philosophical issues related to science education. Subscription rates are $40 per year. Leopold E. Klopfer, Editor, *Science Education*, University of Pittsburgh, Learning Research and Development Center, 3939 O'Hara St., Pittsburgh, PA 15260. To order subscriptions or free sample contact Subscription Department 2-4196, John Wiley & Sons, 605 Third Ave., New York, NY 10158.

Science News.

This 60-year-old science weekly continues its founders' goal "to report newsworthy and timely developments to the public," according to the recent anniversary issue. This issue (March 13, 1982) presents highlights of past issues; regular issues report on the science news of the week and have examined such topics as child abuse in non-human primates (July 10, 1982), computer crime (July 3, 1982), and nuclear physics (August 14, 1982). Subscriptions are $27.50 a year. Joel Greenberg, Editor, *Science News*, 1719 N St. NW, Washington, DC 20036.

Scientific American.

This popular monthly includes non-technical articles on a variety of topics of interest to the scientist and nonscientist. Sections include "Science and the Citizen" and "50 and 100 Years Ago," quotations from 1932 and 1882 issues. Subscriptions are $21 a year. Dennis Flanagan, Editor, *Scientific American*, 415 Madison Avenue, New York, NY 10017.

Strausmanis, Joan, and Watson, Robert F., eds. *A Guide to Undergraduate Science Course and Laboratory Improvements*. Washington, DC: National Science Foundation, 1980.

This book presents one-line descriptions of 804 projects funded by the National Science Foundation's Local Course Improvement (LOCI) and the Instructional Scientific Equipment (ISEP) Programs during 1976–1980. Projects are arranged by subject and state. This volume is useful in identifying colleagues who have experience teaching a wide range of science topics to nonscience majors and employing various instructional approaches and who could serve as speakers or evaluators.

Note to Forum Readers

The *Forum* staff encourages readers to phone or write the person listed after each article for further information on activities at his or her school. Please mention that you are contacting him or her in reference to a *Forum* article. Six months after publication of each issue, we ask feature article contact persons to report on the number of phone calls and letters they have received as a result of their schools' appearance in *Forum*. This tracking system is another measure of the usefulness of various issues and topics addressed by *Forum*.

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The Forum for Liberal Education is a topic-oriented publication featuring a subject of importance for liberal education in each issue. It does not endorse or evaluate institutional activity. Rather, it describes various ways in which institutions of higher learning address important common concerns. Upcoming issues of the *Forum* will look at AAC's Minority Achievement Program and general education. **The *Forum* staff is interested in receiving program information from our readers.** If your school is chosen for inclusion in an issue a staff member will interview a contact person at your school and write the article.

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